An Interesting Tripple Fault Diagnostic Adventure

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A ’90 came to us in horrible running condition. It exhibited the following problems:

- There was white smoke in the exhaust
- Engine error 31 for the cam sensor
- There was stuttering misfire at 3000 rpm and light throttle. The misfire softened a little when enough throttle opening was added to activate the secondary port throttles. Using a data scanner, the misfire could be seen as choppy oxygen sensor cycles on both cylinder banks.

Through our experience we knew that white smoke in the exhaust can be fuel vapor from a fuel injector that is full open at idle. We replaced the ECM and the white smoke and error 31 cleared. That solved problem one.

Now the engine ran only a little rough at idle but it still had the stuttering misfire. I diagnosed it an ignition coil problem. After replacing the coils, we sprayed the fuel injectors because it is easy to do when the plenum is off. The fuel rail was pressurized. Starting at primary #1 we went around and at the last injector, secondary #8, the injector had zero flow. We replaced the secondary #8 injector. Test driving, the stutter was still present but now the engine ran strong at full throttle. This was probably due to the now flowing #8 secondary fuel injector. The new coils did not seem to make any difference.

That solved problem two.

After a lot of driving observations I found that the engine had a misfire with the Full Power mode off from 3000 to 5500 rpm. With the Full Power mode on there was large stumble at 3000 rpm and then the engine ran smooth and strong to 7000 rpm.

I have seen a throttle position sensor cause choppiness as the throttle opened. We replaced the throttle position sensor. There was no change.

Could the misfire be caused by the ignition module? Since the ignition module is hard to change and the crank sensor is easy to change, we replaced the crankshaft sensor first. Driving fifteen minutes later we found that the new crankshaft sensor did not make any difference. So, I installed a new ignition module. It did not make any difference.

Back to test driving and observing, I noticed that the operation of the secondary port throttles actually, in a sense, stopped the misfire. Until then, I thought that the secondaries worked in spite of the misfire. I found that if the secondaries were activated below 3000 rpm the engine operated perfectly. With the Full Power key off it was terrible. There was still a little roughness at idle.

Then it dawned on me that there is an electrical connection between the primary and secondary fuel injectors in the secondary relay modules. When the secondary relays are turned on by the ECM the secondary injectors are driven from the primary injector drivers in the ECM.

I installed a spare secondary relay for module #1. It did not make any difference. I replaced secondary relay module #2 and the engine ran perfectly. No stumble, no misfire, a smooth idle and great power.

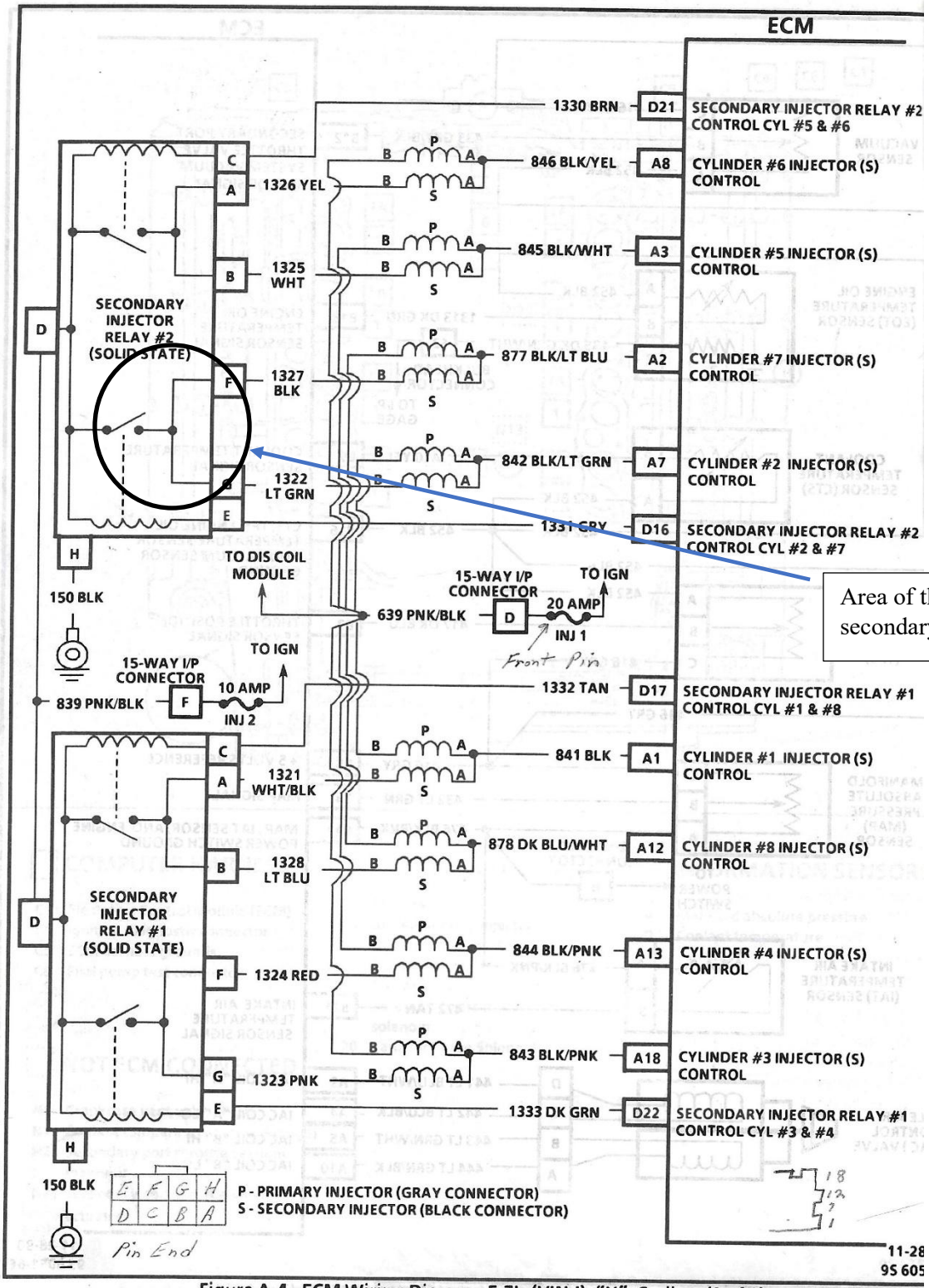
Problem three solved!

Closing Observations

I noticed that the bad ECM had a stock ID number from our shop dated 2023. In 2023 I purchased the ECM from an ECM recycler. It did not work. It blew white smoke at idle and had an error code 31. I returned it to the recycler and they issued a refund for the cost. Fair enough. Then they sold it to the owner of this car.

The secondary relays are little boxes about the size of a deck of cards. They are located under the brake master cylinder and behind the battery on ’90 to ’91 cars. They are mounted on the right wheel house for ’92 and up cars. Although they are called relays in the service documentation, they are really complicated electronic modules with two MOSFET drivers, a 14 pin integrated circuit and 15 diodes. This is only the third failure that I have seen over the approximately 700 ZR-1s that have gone through our shop. The other two failures affected only the operation of the secondary fuel injectors.

More About the Secondary Relays



Area of the failure in the secondary relay module.

Figure A-4 - ECM Wiring Diagram 5.7L (VIN J) "Y" Carline (2 of 8)

GM depicts it logically as a pair of mechanical relays. I cut the box open to see if anything was obviously wrong with it. In reality it is a complex electrical circuit. It passed physical inspection. Since there were so many diodes, and diodes are easy to test with an ohm meter, checked them. A diode conducts current in one direction only. The battery in the ohm meter will forward bias the diode and the meter will show low resistance. If the meter leads are reversed the voltage applied to the diode is reversed and it will show very little current flow/resistance.

I observed that the diode pointed to in the picture, had no current flow in both directions. It could not be forward biased. It's a common 1N4002 diode. I replaced it, and tested the secondary relay in a car. The secondary relay now has a new life!